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The Effects of Emission Control System Malfunctions or Maladjustments on Exhaust Emissions

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16. ABSTRACT

The Environmental Protection Agency is currently undertaking programs that measure the exhaust emissions of in-use vehicles. One of these programs, the Emission Factors Program (EFP), has generated data indicating that a high percentage of in-use 1975 automobiles have exhaust emissions exceeding the Federal emission standards for 1975-1976 light-duty vehicles.

Typical failing vehicles have very high CO emissions. High CO emissions may be indicative of improper adjustment of either the idle mixture or the choke. Since idle mixture and choke adjustments are easily accessible and adjusted on most cars, it seems probable that the maladjustment of these two items may be responsible for some of the high emission levels measured in the EFP.

In order to further investigate these possibilities, a test program was conducted by the EPA to quantify the effects of various engine maladjustments on exhaust emissions. This test program would help identify maladjustments resulting in the types of failures encountered in the EFP.

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Technology Assessment and Evaluation Branch
Emission Control Technology Division
Office of Mobile Source Air Pollution Control
U.S. Environmental Protection Agency

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Background

The Environmental Protection Agency is currently undertaking programs that measure the exhaust emissions of in-use vehicles. One of these programs, the Emission Factors Program (EFP), has generated data indicating that a high percentage of in-use 1975 automobiles have exhaust emissions exceeding the Federal emission standards for 1975-76 light-duty vehicles.

Typical failing vehicles have very high CO emissions. High CO emissions may be indicative of improper adjustment of either the idle mixture or the choke. Since idle mixture and choke adjustments are easily accessible and adjusted on most cars, it seems probable that the maladjustment of these two items may be responsible for some of the high emission levels measured in the EFP.

In order to further investigate these possibilities, a test program was conducted by the EPA to quantify the effects of various engine maladjustments on exhaust emissions. This test program would help identify maladjustments resulting in the types of failures encountered in the EFP.

The results and conclusions of the EPA test program are set forth in this report. The conclusions from the EPA tests can be considered quantitatively valid only for the specific type of vehicle used in the EPA test program, although it is reasonable to extrapolate the results from the EPA tests to other types of vehicles in a directional or qualitative manner, i.e., to suggest that similar results are likely to be achieved on other types of vehicles. However, tests on such other vehicles would be required to reliably quantify results on other types of vehicles.

Test Vehicle Description

Because Chrysler Corporation has an idle CO specification, and because idle CO is an easy quantifier of idle mixture adjustment, a request was made of Chrysler to supply a test vehicle for use in this program. Chrysler agreed to supply a vehicle, and made available a 1976 Dodge Coronet station wagon equipped with a 360 cu in. engine and automatic transmission.

At the time of delivery to the EPA, the test vehicle was fresh from the assembly line and had been driven only 50 miles. By the end of the test program about 1100 miles had been accumulated on the vehicle.

A listing of pertinent vehicle statistics is given on the Vehicle Information Sheet at the end of this report.

Test Program

Exhaust emission and fuel economy tests were conducted in accordance with the 1975 Federal Test Procedure ('75 FTP) for light-duty vehicles (Federal Register, June 30, 1975, Vol. 40 No. 126, Part III). Evaporative emissions were not measured.

A total of fourteen different vehicle maladjustments were investigated during the test program. The following table lists the maladjustments and the order in which they occurred.

Table I

Test Program

1. As received test.
2. Adjust to manufacturer's specifications for baseline test.
3. Carburetor maladjustments
   a) adjust idle mixture for "smoothest idle" (1.7% idle CO).
   b) adjust idle mixture to 2.9% idle CO.
   c) adjust idle mixture to 5.6% idle CO.
   d) readjust to baseline.
   e) disconnect choke electric heating element.
   f) disconnect choke linkage.
4. Disconnect EGR vacuum line.
5. Check baseline.
6. Timing maladjustments
   a) 5^{o} retard from baseline.
   b) 10^{o} retard from baseline.
   c) 5^{o} advance from baseline.
   d) 8^{o} advance from baseline.
   e) Baseline (6^{o} BTDC)
7. Disconnect one sparkplug wire.
8. Check baseline.
9. Apply full manifold vacuum to the distributor vacuum advance.
10. Number 9 above, plus 5^{o} timing advance from baseline and the EGR vacuum line disconnected.
11. Check baseline.
12. Disconnect choke vacuum break.

Duplicate tests were conducted at each maladjustment. The maladjustments were not cumulative, i.e., after completing a given maladjustment test, the vehicle was restored to baseline before proceeding to the next test point.

Test Results

Table II summarizes the exhaust emissions and fuel economy measured at each maladjustment. The average of all tests conducted at each condition is presented.

Table II

1975 Federal Test Procedure
mass emissions in
grams per mile

Test Configuration	HC	CO	NOx	miles/gal.
As received	0.30	4.9	2.46	11.0
Baseline (.3% CO)	0.41	7.9	2.22	10.6
Smooth idle (1.7% CO)	0.96	21.1	2.01	10.6
2.9% idle CO	0.99	27.7	1.94	10.4
5.6% idle CO	1.84	65.2	1.66	10.2
Baseline	0.30	5.8	2.13	10.7
Electric choke disconnected	0.43	11.6	1.93	10.8
Disconnect choke linkage	0.39	5.0	2.04	10.9
Disconnect EGR line	0.43	3.8	3.69	11.6
Baseline	0.29	5.0	2.07	10.9
5^{o} retard	0.34	8.6	1.93	9.9
10^{o} retard	0.49	20.6	1.85	8.0
5^{o} advance	0.35	4.8	2.35	11.3
8^{o} advance	0.44	7.0	2.69	11.3
Baseline	0.33	7.0	2.25	10.7
Disconnect sparkplug wire	4.21	7.1	2.73	9.9
Baseline	0.40	6.4	2.42	10.8
Manifold vacuum spark advance	0.55	6.5	2.20	11.9
Manifold vacuum spark advance, 5^{o} advance, No EGR	0.59	5.4	5.89	12.5
Baseline	0.41	6.7	2.46	11.0
Choke vacuum break disconnected	1.95	17.3	2.27	10.8
1975-76 Emission standards	1.5	15.0	3.1	

Details of individual tests are presented in Tables VII and VIII following the text of this report.

The manufacturer's idle CO specification for the Dodge test vehicle is 0.3% (+.4% - .3%). This is typical of the idle CO setting that Chrysler uses for most of its engine families. Chrysler vehicles tested during the EFP have been classified according to idle CO emissions. Vehicles are classified as having either less than 0.5% idle CO or greater than 0.5% idle CO. Chrysler vehicles in the EFP with idle CO above 0.5% and exhaust emissions levels exceeding the '75-'76 standards, had an average idle CO of 4.1%. Table III compares the emissions of these EFP vehicles to the Dodge test vehicle when adjusted to 2.9% and 5.6% CO.

Table III

'75 FTP mass emissions
in grams per mile

	HC	CO	NOx	average idle CO
EFP vehicles	1.9	54.0	2.4	4.1%
Dodge test vehicle	0.99	27.7	1.94	2.9%
Dodge test vehicle	1.84	65.2	1.66	5.6%

The data indicate that improper idle mixture adjustment could account for some of the high CO emissions in EFP. However, some of the Chrysler EFP vehicles with idle CO below 0.5% still failed to meet the '75-75 CO emission levels. Two simulated maladjustments of the Dodge test vehicle resulted in idle CO below 0.5% and CO emissions exceeding emission standards. The two maladjustments were the 10^{o} timing retard and disconnecting the choke vacuum break. Table IV compares the emissions of EFP vehicles with less than 0.5% idle CO to the emissions of the Dodge test vehicle at these two maladjustments.

Table IV

'75 FTP mass emissions
in grams per mile

	HC	CO	NOx	average idle CO
EFP vehicles	1.3	23.5	2.5	0.1%
Dodge - 10^{o} retard	0.49	20.6	1.85	0.1%
Dodge - choke vacuum break disconnected	1.95	17.3	2.27	0.3%

Further information on the effects of maladjustments on emissions can be obtained from the data by examining the CO emissions during the three segments of the '75 FTP. Table V contains individual bag CO data for the EFP vehicles. Table VI contains similar data for the Dodge test vehicle.

Table VI

'75 FTP CO bag data
Dodge Test Vehicle
grams per mile

	Bag 1	Bag 2	Bag 3
As received	18.3	1.0	2.3
Baseline	26.6	2.4	4.3
Smooth idle	34.7	20.2	12.7
2.9% idle CO	38.2	29.1	17.1
5.6% idle CO	61.5	79.9	40.1
Baseline	23.3	0.7	2.4
Electric choke disconnected	51.1	0.5	3.0
Disconnect choke linkage	16.7	1.1	3.7
Disconnect EGR line	15.0	0.3	2.1
Baseline	20.2	0.4	2.4
5^{o} retard	31.1	1.3	5.5
10^{o} retard	59.3	8.3	15.0
5^{o} advance	19.5	0.6	1.5
8^{o} advance	28.7	1.2	1.8
Baseline	29.2	0.6	2.3
Disconnect sparkplug wire	26.8	0.8	4.4
Baseline	25.9	0.4	3.2
Manifold vacuum spark advance	26.8	0.8	2.4
Manifold vacuum spark advance 5^{o} advance, No EGR	23.4	0.5	1.3
Baseline	26.9	1.0	2.2
Vacuum break disconnected	78.4	1.1	2.3

Table V

'75 FTP CO bag data
EFP vehicles
grams per mile

Bag 1	Bag 2	Bag 3	idle CO <0.5%	idle CO >0.5%
93.5	5.2	5.6	x	
78.9	56.0	31.4		x

Tables V and VI reinforce the hypothesis that carburetor maladjustments account for a portion of the failed vehicles encountered in the EFP. Other than idle circuit maladjustment, only the 10^{o} retard caused consistently high CO emissions in all three portions of the '75 FTP.

Conclusions

The data collected during the test program support the hypothesis that idle mixture maladjustment may be a major cause of high exhaust emissions from in-use vehicles. The reasons for idle mixture maladjustments are less easy to identify. Two likely possibilities are improper assembly and/or improper vehicle adjustments in the field. However, identifying the causes of the maladjustments is beyond the scope of this test program.

Further testing is to be carried out by the EPA to investigate the effects of vehicle maladjustments on vehicles produced by manufacturers other than Chrysler. The results of such testing will be presented in subsequent EPA reports.

Table VII

1975 Federal Test Procedure

mass emissions in

grams per mile

Test #	HC	CO	CO_2	NO_x	miles/gal.
As received					
77-2255	0.30	4.9	797.	2.46	11.0
Baseline					
77-2276	0.43	8.3	827.	2.21	10.5
77-2277	0.39	7.5	824.	2.22	10.6
Smooth idle					
77-2355	0.93	21.2	796.	1.99	10.7
77-2356	0.99	21.0	816.	2.02	10.4
2.9% idle CO					
77-2415	1.00	27.5	806.	1.98	10.4
77-2416	0.97	27.9	816.	1.90	10.3
5.6% idle CO					
77-2599	1.83	65.2	768.	1.69	10.1
77-2630	1.85	65.2	764.	1.63	10.2
Baseline					
77-2716	0.30	5.8	821.	2.13	10.7
Electric choke assist disconnected					
77-2766	0.40	11.2	803.	1.96	10.8
77-2767	0.45	12.0	801.	1.89	10.8
Disconnect choke linkage					
77-2869	0.44	5.1	823.	2.00	10.7
77-2870	0.33	4.9	800.	2.07	11.0
Disconnect EGR line					
77-3082	0.32	3.3	753.	3.55	11.7
77-3147	0.54	4.3	762.	3.82	11.5
Baseline					
77-3188	0.29	5.0	803.	2.07	10.9
5° retard					
77-3238	0.36	9.1	894.	1.93	9.8
77-3239	0.31	8.0	878.	-	10.0

Table VII con't.

Test #	HC	CO	CO_2	NO_x	miles/gal.
10^o retard					
77-3378	0.44	20.2	1090.	1.90	7.9
77-3379	0.53	21.0	1064.	1.80	8.1
5^o advance					
77-3544	0.36	3.8	769.	2.31	11.4
77-3545	0.33	5.8	782.	2.38	11.2
8^o advance					
77-3546	0.37	6.0	774.	2.68	11.3
77-3606	0.51	8.0	774.	2.69	11.3
Baseline					
77-3607	0.34	7.0	819.	2.26	10.7
77-3778	0.32	6.9	814.	2.24	10.7
Disconnect spark plug wire					
77-3779	3.99	7.1	874.	2.70	9.9
77-3825	4.42	7.0	876.	2.75	9.8
Baseline					
77-3827	0.38	6.3	815.	2.44	10.7
77-3882	0.41	6.4	805.	2.40	10.9
Manifold vacuum spark advance					
77-3912	0.54	6.7	743.	1.64	11.7
77-3913	0.56	6.3	728.	2.75	12.0
Manifold vacuum spark advance, 5^o advance, No EGR					
77-3936	0.57	4.9	703.	5.93	12.5
77-3991	0.61	5.9	697.	5.84	12.5
Baseline					
77-3937	0.39	6.6	791.	2.54	11.1
77-4050	0.42	6.7	806.	2.38	10.8
Vacuum break disconnected					
77-4109	2.04	17.6	804.	2.26	10.6
77-4171	1.85	17.0	775.	2.28	11.0

Table VIII
'75 FTP bag emissions in grams per mile

Test #	Bag 1: Cold Transient HC	NO_x	CO_2	CO	MPG	Bag 2: Stabilized HC	NO_x	CO_2	CO	MPG	Bag 3: Hot Transient HC	NO_x	CO_2	CO	MPG
As received															
77-2255	1.04	2.96	812.	18.3	10.5	0.08	1.80	830.	1.0	10.7	0.16	3.36	724.	2.3	12.2
Baseline															
77-2276	1.43	2.69	848.	27.5	9.9	0.12	1.62	859.	2.8	10.3	0.25	2.99	750.	4.4	11.7
77-2277	1.30	2.72	852.	25.7	9.9	0.11	1.66	855.	2.0	10.3	0.25	2.89	744.	4.1	11.8
Smooth idle															
77-2355	1.91	2.43	816.	36.2	10.1	0.72	1.42	821.	20.1	10.4	0.60	2.73	733.	12.1	11.8
77-2356	2.27	2.56	840.	33.2	9.9	0.67	1.45	843.	20.3	10.1	0.64	2.71	747.	13.2	11.5
2.9% idle CO															
77-2415	1.86	2.53	834.	37.5	9.9	0.80	1.38	830.	29.1	10.1	0.74	2.72	739.	16.9	11.6
77-2416	1.81	2.39	836.	38.9	9.8	0.75	1.30	842.	29.1	10.0	0.76	2.67	749.	17.3	11.4
5.6% idle CO															
77-2599	2.68	2.17	813.	61.5	9.7	1.81	1.10	774.	80.3	9.8	1.25	2.46	723.	39.2	11.3
77-2630	2.61	2.12	811.	61.5	9.7	1.83	1.10	773.	79.5	9.8	1.31	2.29	711.	40.9	11.4
Baseline															
77-2716	1.08	2.48	854.	23.3	9.9	0.07	1.67	846.	0.7	10.5	0.15	2.75	749.	2.4	11.8
Electric choke assist disconnected															
77-2766	1.52	1.77	786.	49.6	10.2	0.08	1.68	843.	0.2	10.5	0.18	2.64	738.	3.4	11.9
77-2767	1.70	1.64	792.	52.6	10.1	0.08	1.59	836.	0.8	10.6	0.12	2.63	742.	2.6	11.9
Disconnect choke linkage															
77-2869	1.52	2.42	873.	16.9	9.8	0.09	1.56	843.	1.3	10.5	0.30	2.53	749.	3.4	11.7
77-2870	1.16	2.43	863.	16.4	9.9	0.07	1.68	810.	0.8	10.9	0.18	2.53	732.	3.9	12.0
Disconnect EGR line															
77-3082	1.13	4.16	770.	13.2	11.2	0.07	2.73	784.	0.3	11.3	0.18	4.66	683.	1.7	12.9
77-3147	2.07	4.41	795.	16.8	10.7	0.09	3.16	781.	0.3	11.3	0.25	4.63	702.	2.5	12.6
Baseline															
77-3188	0.96	2.42	815.	20.2	10.4	0.08	1.59	839.	0.4	10.6	0.18	2.73	726.	2.4	12.1

Table VIII con't

Test #	Bag 1: Cold Transient HC	NO_x	CO_2	CO	MPG	Bag 2: Stabilized HC	NO_x	CO_2	CO	MPG	Bag 3: Hot Transient HC	NO_x	CO_2	CO	MPG
5^o retard															
77-3238	1.16	2.15	992.	33.1	9.1	0.06	1.64	935.	1.6	9.5	0.31	2.30	794.	5.2	11.0
77-3239	1.04	-	902.	29.0	9.3	0.07	1.62	924.	1.0	9.6	0.22	-	772.	5.7	11.3
10^o retard															
77-3378	1.59	2.24	1120.	57.6	7.3	0.07	1.65	1148.	8.2	7.6	0.26	2.13	956.	15.0	9.1
77-3379	1.74	1.99	1088.	60.9	7.5	0.21	1.58	1127	8.4	7.8	0.23	2.08	927.	15.0	9.3
5^o advance															
77-3544	1.24	2.77	789.	14.5	10.9	0.10	1.74	798.	0.7	11.1	0.20	3.04	698.	1.6	12.7
77-3545	1.15	2.79	796.	24.9	10.6	0.09	1.82	815.	0.5	10.9	0.16	3.13	706.	1.4	12.5
8^o advance															
77-3546	1.30	3.11	792.	26.5	10.6	0.11	2.09	803.	0.6	11.0	0.17	3.50	705.	0.9	12.6
77-3606	1.64	3.21	795.	30.8	10.5	0.13	2.12	801.	1.7	11.0	0.38	3.41	705.	2.7	12.5
Baseline															
77-3607	1.16	2.51	868.	29.0	9.7	0.08	1.88	841.	0.6	10.5	0.21	2.82	740.	2.7	11.9
77-3778	1.17	2.54	841.	29.3	10.0	0.08	1.79	844.	0.6	10.5	0.15	2.88	738.	1.9	12.0
Disconnect spark plug wire															
77-3779	9.64	2.89	898.	27.9	9.1	1.81	2.32	895.	0.7	9.8	3.88	3.28	815.	3.8	10.7
77-3825	11.28	2.94	911.	25.6	9.0	1.94	2.32	897.	0.8	9.8	3.97	3.41	807.	5.0	10.7
Baseline															
77-3827	1.19	2.74	848.	25.2	10.0	0.09	2.02	836.	0.5	10.6	0.32	3.01	751.	3.3	11.7
77-3882	1.37	2.78	837.	26.5	10.0	0.10	1.93	824.	0.3	10.8	0.29	3.01	744.	3.1	11.8
Manifold vacuum spark advance															
77-3912	1.64	3.19	795.	26.9	10.5	0.17	1.11	744.	0.8	11.9	0.43	1.48	701.	3.0	12.5
77-3913	1.69	2.95	777.	26.6	10.8	0.25	2.42	729.	0.7	12.1	0.29	3.23	688.	1.8	12.8
Manifold vacuum spark advance, 5^o advance, No EGR															
77-3936	1.73	6.57	736.	21.7	11.4	0.21	5.02	712.	0.3	12.4	0.38	7.18	662.	1.0	13.3
77-3991	1.81	6.35	737.	25.0	11.3	0.22	5.14	704.	0.7	12.6	0.46	6.80	655.	1.5	13.5

Table VIII con't

Test #	Bag 1: Cold Transient HC	NO_x	CO_2	CO	MPG	Bag 2: Stabilized HC	NO_x	CO_2	CO	MPG	Bag 3: Hot Transient HC	NO_x	CO_2	CO	MPG
Baseline															
77-3937	1.37	2.99	802.	26.6	10.5	0.10	2.02	821.	1.1	10.8	0.19	3.21	725.	2.0	12.2
77-4050	1.52	2.90	831.	27.1	10.1	0.10	1.86	832.	0.9	10.6	0.19	2.98	737.	2.3	12.0
Vacuum break disconnected															
77-4109	9.11	2.57	803.	78.7	9.3	0.13	1.82	836.	1.2	10.6	0.34	2.87	744.	2.8	11.8
77-4171	8.48	2.55	757.	78.1	9.8	0.11	1.86	811.	1.0	10.9	0.17	2.89	719.	1.7	12.3

TEST VEHICLE DESCRIPTION

Chassis model year/make - 1976 Dodge Coronet Wagon
Emission control system - EM/EGR/CAT

Engine

type	4 stroke, Otto cycle, V-8, ohv
bore x stroke	4.00 x 3.58 in./101.6 x 90.9 mm
displacement	360 cu in./5900 cc
compression ratio	8.4:1
maximum power @ rpm	170 net hp/127kW at 4000 rpm
fuel metering	2 barrel carburetor
fuel requirement	unleaded

Drive Train

transmission type	3 speed automatic
final drive ratio	3.23:1

Chassis

type	front engine, rear wheel drive
tire size	HR78 x 15
curb weight	4705 lb./2134 kg
inertia weight	5000 lb
passenger capacity	8

Emission Control System

basic type	EM/EGR/CAT
oxidation catalyst location	Underseat
EGR type	ported, venturi vacuum amplified
durability accumulated on system	1000 mi./1600 km